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System Dynamics Group

The BOSTON Project

Discussion Paper #8
Assessing Boston's Housing Strategies
by Louis Edward Alfeld

Just how much progress has Boston made over the past decade? How much progress does Boston expect to make over the next decade? Such simple questions do not have simple answers. What is progress? Relative to what? Suppose we limit the scope of our questions to changes in housing and income of Boston residents relative to metropolitan residents. How has income distribution shifted in Boston relative to income shifts in the metropolitan area? How has Boston's housing stock changed in relation to shifts in city population composition? What future changes in housing will occur? What housing strategies best meet Boston's population and income goals?

The following four sections develop a structural framework for measuring change in Boston's housing stock and population composition. Section 1 discusses changes in city population composition; Section 2 relates those changes to a simple model of Boston's housing stock. Section 3 presents a complex model of housing change in Boston. Section 4 illustrates how to use the model for assessing alternative housing strategies.

1. Comparing Boston to the Metropolitan Area

Comparisons between Boston and the metropolitan area depend on judgments of changes in relative positions. Some people intuitively judge that Boston's socio-economic status has slipped over the past decade while others believe the city has gained. Some figures help clarify the reasoning behind these diverse opinions.

Statistics Tell a Partial Story. Census data from 1960 and 1970 tell only a partial, and perhaps confusing, story of relative changes between Boston and the metropolitan area. Data revealing that Boston households earning less than $6000/year (in constant 1970 dollars) declined from 45.8% in 1960 to 38% by 1970 shows progress in upgrading the incomes of Boston residents. But the same data reveals that within the metropolitan area, $6000/year and under households declined from 33.2% to 26.3%. Did Boston do as well as the metropolitan area? Yes and No. Although Boston retained a disproportionate share of low-income households, Boston's share dropped 7.8 percentage points while the number of low-income households in the metropolitan area dropped only 6.9 percentage points. One can present the statistics in ways to show either progress or lack of it depending upon the purpose at hand. If we wish to assess Boston's progress relative to metropolitan progress, for example, then we must restructure the data to establish a metropolitan index to measure relative changes in Boston.

Concept of Metropolitan Index. Gauging relative change in Boston's population and housing stock requires an index analogous to a

consumer price index used to adjust dollar values over time. A consumer price index utilizes floating dollar values as a base to measure real changes in prices; the index relates inflationary price changes to current dollar prices. In the same way, we wish to adjust Boston's gains in resident incomes and housing stock values against a scale of rising metropolitan incomes. The resulting measurement of changes in Boston will show how the city fared relative to the rising metropolitan average.

How the Metropolitan Index Works. To establish a metropolitan index, we begin by examining metropolitan household income changes between 1960 and 1970. In 1960, households earning 0 - $5,000/year comprised 26.4% of the metropolitan population. In 1970, the income of the lower 26.4% of metropolitan households rose to 0 - $6,000/year. If we define low income as the lower 26.4% of metropolitan households, then low income households earned 0 - $5,000 in 1960 and 0 - $6,000 in 1970. In Boston, 84,000 households earned below $5,000 in 1960 (37.1% of all households). By 1970, 83,000 households (38% of all households) earned below $6,000. Figure 1, on page 4, presents a simple graph showing that between 1960 and 1970, Boston's share of low income households remained fairly constant relative to our floating metropolitan index that holds the metropolitan share of low income households constant. So during the '60-'70 decade, Boston's low income population neither increased or decreased nor did the metropolitan

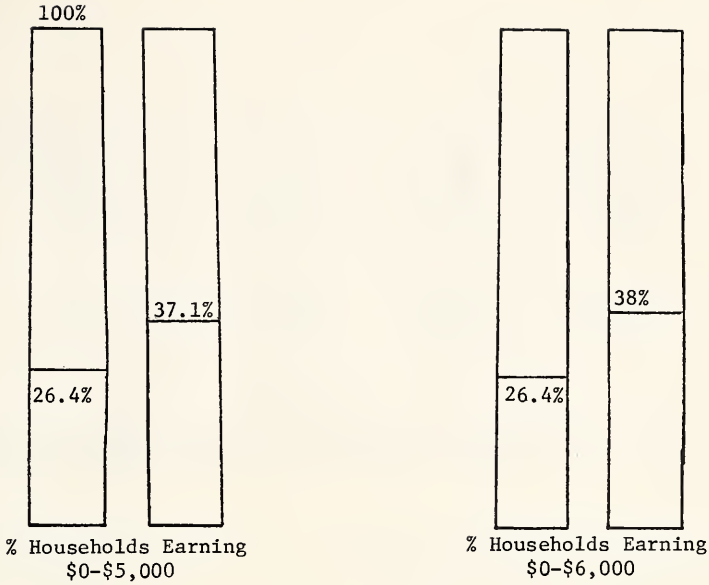

Figure 1
A Floating Scale Defines Boston's Fraction of Low Income Population Against Rising Metropolitan Incomes

area's low income population. Similar calculations show that metropolitan moderate income households earning $5,000 - $10,000/year in 1960 comprise 41.7% of all metropolitan households. By 1970, the incomes of this middle 41.7% rose to $6,000 - $13,500; these figures also establish the income range for defining Boston's moderate income households. Remaining households are classed as middle and high income, two separate categories combined here for ease of calculation from available data.

Classifying Population by Economic Status. Figure 2, on page 5, shows changes in the economic status of the classes of Boston's households, high and middle income, moderate income and low income,

	High and Middle Income	Moderate Income	Low Income	Total Households
1960	48,000	93,000	84,000	225,000
%	21.4%	41.5%	37.1%	100%
1970	42,000	93,000	83,000	218,000
%	19.2%	42.7%	38%	100%

Figure 2
Changes in Household Income Distribution in Boston, 1960-1970, Adjusted to a Floating Metropolitan Income Scale

between 1960 and 1970 scaled to a floating metropolitan index. The income lines which separate the three population classes change between 1960 and 1970 to reflect rising metropolitan incomes. In 1960, 0 - $5,000/year defines low income, $5,000 - $10,000/year defines moderate income, and $10,000/year and above defines high and middle income households. In 1970, 0 - $6,000/year defines low income, $6,000 - $13,500/year defines moderate income and $13,500/year and above defines high and middle income households.

Summary. Changes in the income distribution of Boston households between 1960 and 1970 show Boston household incomes shifting slightly downward. The loss of 6,000 high and middle income households shown in Figure 2 lowered the fraction of households at the upper end of the scale while increasing the fraction at the lower end of the scale. Relative to rising metropolitan incomes, therefore, average incomes of Boston residents were lower in 1970 than in 1960. Whether Boston regained some of its losses in the 1970-1973 period remains speculative.

2. Households and Houses

We can apply the relative metropolitan index concept used to measure changes in household income to measure changes in city housing stock. We divide housing into three categories depending on occupant income: upper and middle income, moderate income, and low income. Note that this definition does not measure absolute housing quality, only relative position of housing in metropolitan and city markets.

Changes in Housing Stock. Between 1960 and 1970, Boston's housing stock matched city population in that all city housing units fell into one of the three categories proportionate to the number of households. Figure 3 shows distribution of housing proportionate to occupant income class.

	High and Middle Income Housing	Moderate Income Housing	Low Income Housing	Total Housing Units
1960	51,500 22%	99,000 41%	88,100 37%	238,600 100%
1970	44,000 19%	98,000 42%	90,000 39%	232,000 100%

Figure 3
Boston's Housing Stock, 1960-1970, Proportionate to Changes in Occupant Incomes.*

*Allowance made for variations in average household size and differential vacancy rates among the three categories.

Housing Rates and Housing Levels. Urban dynamics methodology differentiates between rates and levels in analysis of changes in system conditions. The housing categories shown in Figure 3 above are levels. Only rates can change levels; housing rates are construction, demolition, rehabilitation, and filter-down. Figure 4 shows a simple model of housing including rates and levels.

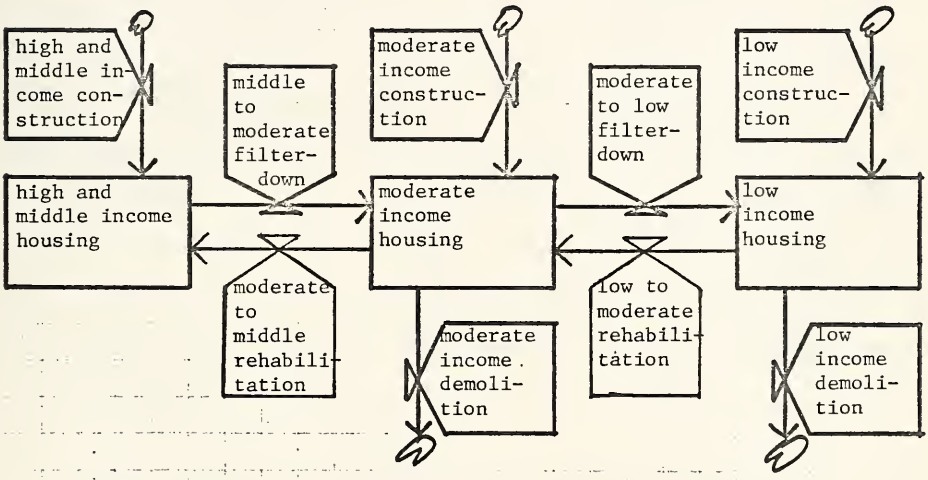

Figure 4
An Urban Dynamics Model of Housing
Rates and Levels.

Analyzing Changes in Boston's Housing Stock. The simple model shown in Figure 4 reveals how the rates changed housing levels between 1960 and 1970. Given data on changes in levels from Figure 3 above and data for construction and demolition rates, model analysis reveals significant net rates of housing rehabilitation filter-down

between 1960 and 1970. Figure 5, which summarizes model results, shows only net rates of filter-down. In reality rehabilitation moved some units upward while more filtered down. Because precise data is unavailable,

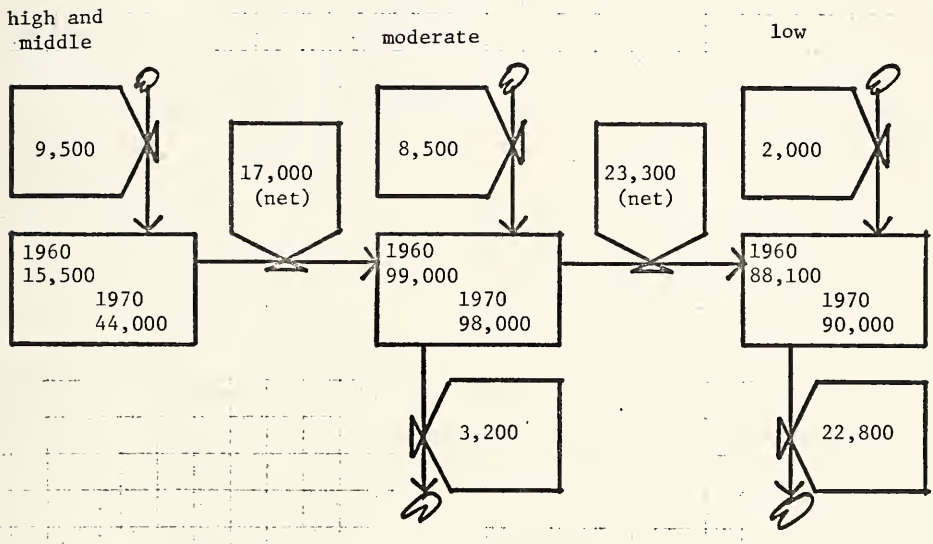

Figure 5
Summary of Changes in Boston's Housing Stock, 1960-1970.

only net rates appear. In Figure 5, the net rate of filter-down of moderate income units to low income units exceeds the rate of low income housing demolition. This difference accounts for the net gain of low income housing in Boston between 1960 and 1970. Continued filter-down of Boston's vast stock of moderate income housing will provide a large stock of low income housing in Boston's future. More detailed examination of changes in Boston's housing stock, and analysis of housing policy alternatives, requires a more disaggregated housing model.

3. Constructing a Housing Model

A computer simulation model of Boston's housing can play a constructive role in the evaluation of alternative strategies designed to alter housing conditions in the city. The model disaggregates housing into 9 levels controlled by 19 rates.

Categorizing Housing by Type. Besides classification by income of residents, the housing model categorizes Boston's housing stock according to three structural types:

a. Masonry Structures -- buildings in Beacon Hill, Back Bay, Charlestown and South End typify solid structures built to last and amenable to rehabilitation;

b. Wood Structures -- three-decker houses, covering most of Boston, reflect turn-of-the-century construction now rapidly aging and generally less economical for major rehabilitation; and

c. High Density Apartment Structures -- post-depression construction, mostly high-rise or garden apartments, now comprise virtually all new construction in Boston.

The housing model, therefore, contains 9 levels of housing, illustrated in Figure 6 on page 10. Each of the three classes of housing exhibits different characteristics with respect to the rates controlling the stock. Differences in rates of construction, rehabilitation, filter-down, and demolition define the class into which any individual structure falls. While grey areas between classes exist, a desire to simplify our model led to inclusion of only the 9 levels and 19 rates shown in Figure 7 on page 11.

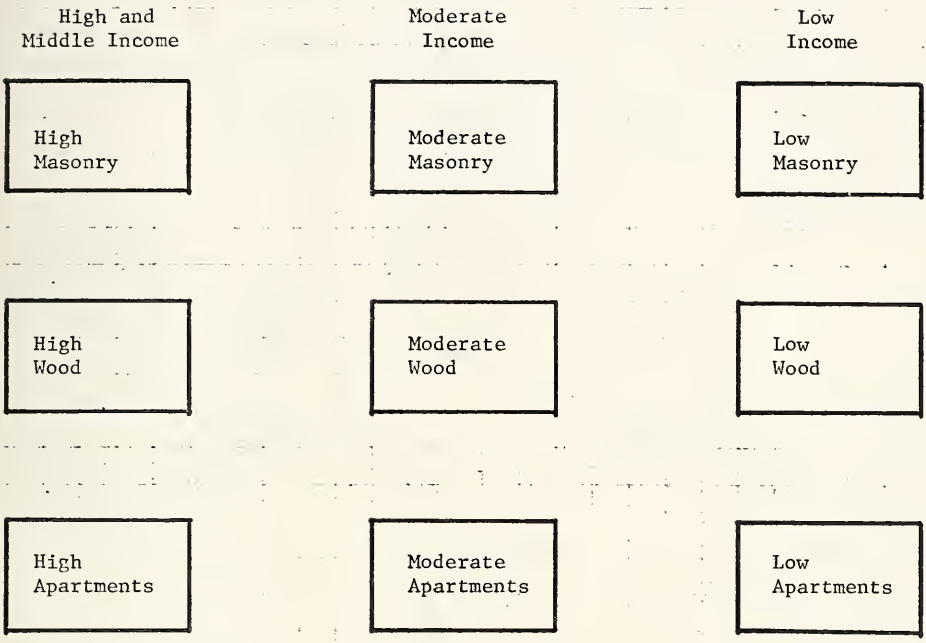

Figure 6
Nine Levels Disaggregate Boston's Total Housing Stock
By Income and Structural Type Categories.

Model Rates. Four types of rates control the flow of housing units through the housing model: construction, demolition, rehabilitation and filter-down. Figure 7, on page 11, shows a total of 19 rates in the model. The model excludes construction rates for heavy masonry structures of the type found in Back Bay or the South End, but

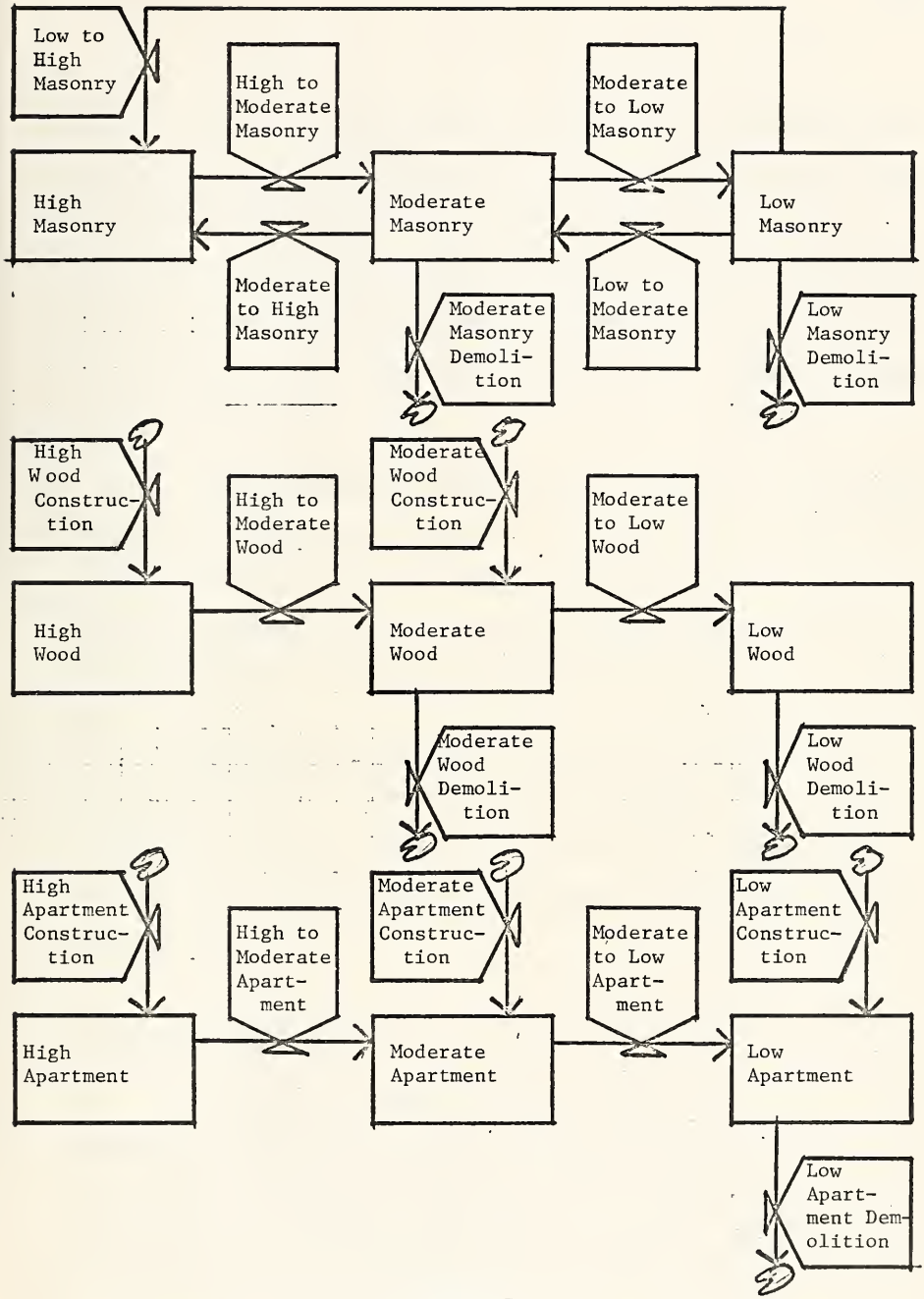

Figure 7
Nine Levels and Nineteen Rates Comprise the Boston Housing Model

does include rehabilitation and filter-down rates for these structures. Filter-down of housing in the wood and apartment categories constitutes a net flow; whatever rehabilitation occurs is too small a quantity to warrant explicit representation. The model in Figure 7 also excludes other rates, such as demolition of high income structures or construction of low income wood structures because they have negligible influence on system behavior.

Boston's Housing in 1960. Figure 8, on page 13, shows system conditions in 1960 corresponding to actual Boston data for 1960. The numbers in each level symbol (rectangle) represent units of housing in that category in 1960; the percentage number is the fraction of total housing stock represented by that level.

Boston's Housing 1960-1970. Figure 9, on page 14, shows system conditions in 1970 as simulated by the housing model. The numbers within each rate symbol (valve) represent the 10-year total for that rate. When compared to actual Boston data, the model errs by less than 2%.

4. Testing Housing Policy

Housing policy influences system rates which, in turn, change housing levels. Policies to increase or decrease rates, therefore, appear as increases or decreases over the 1960-1970 values of the rates. To illustrate application of the model to policy analysis,

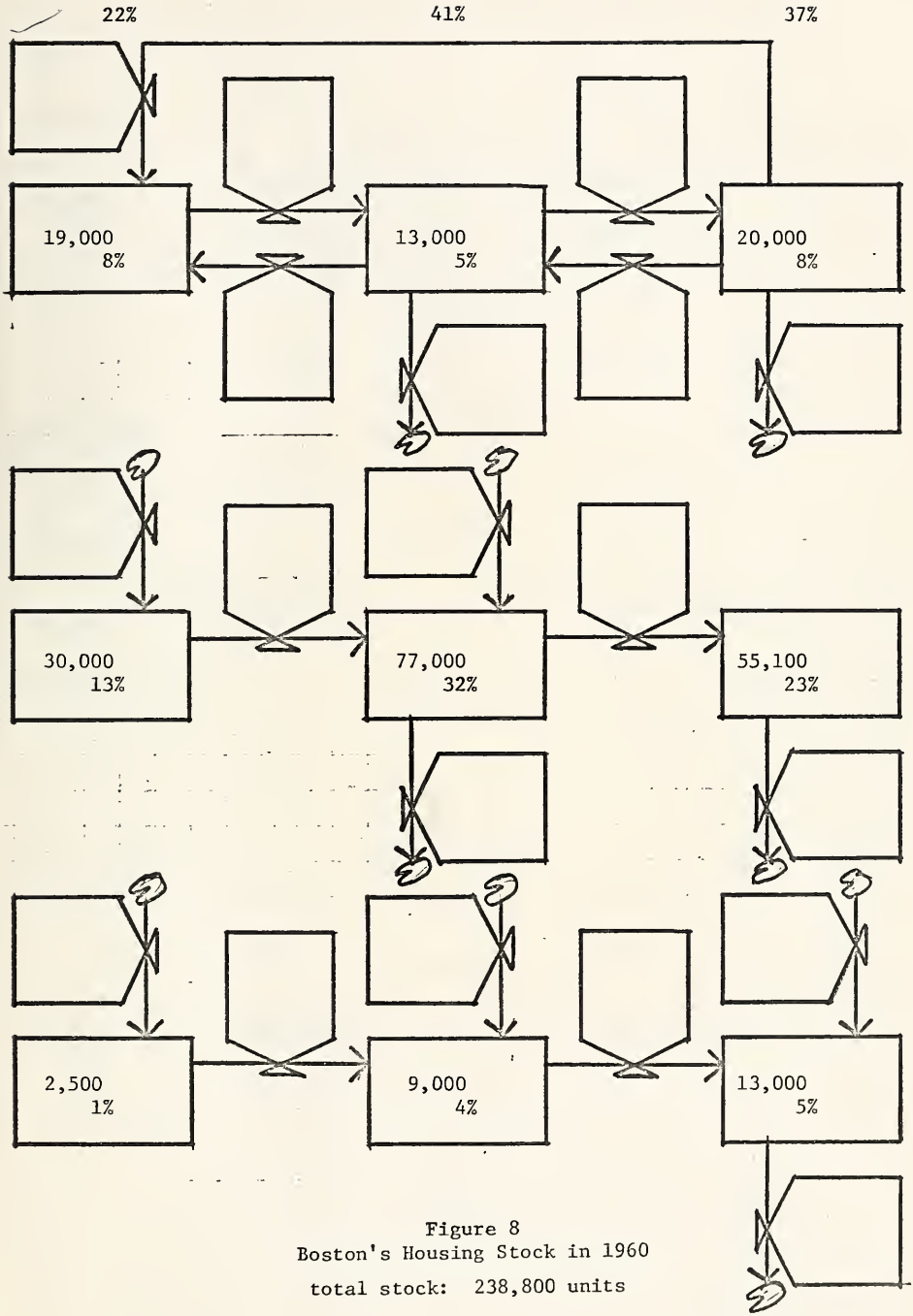

Figure 8
Boston's Housing Stock in 1960
total stock: 238,800 units

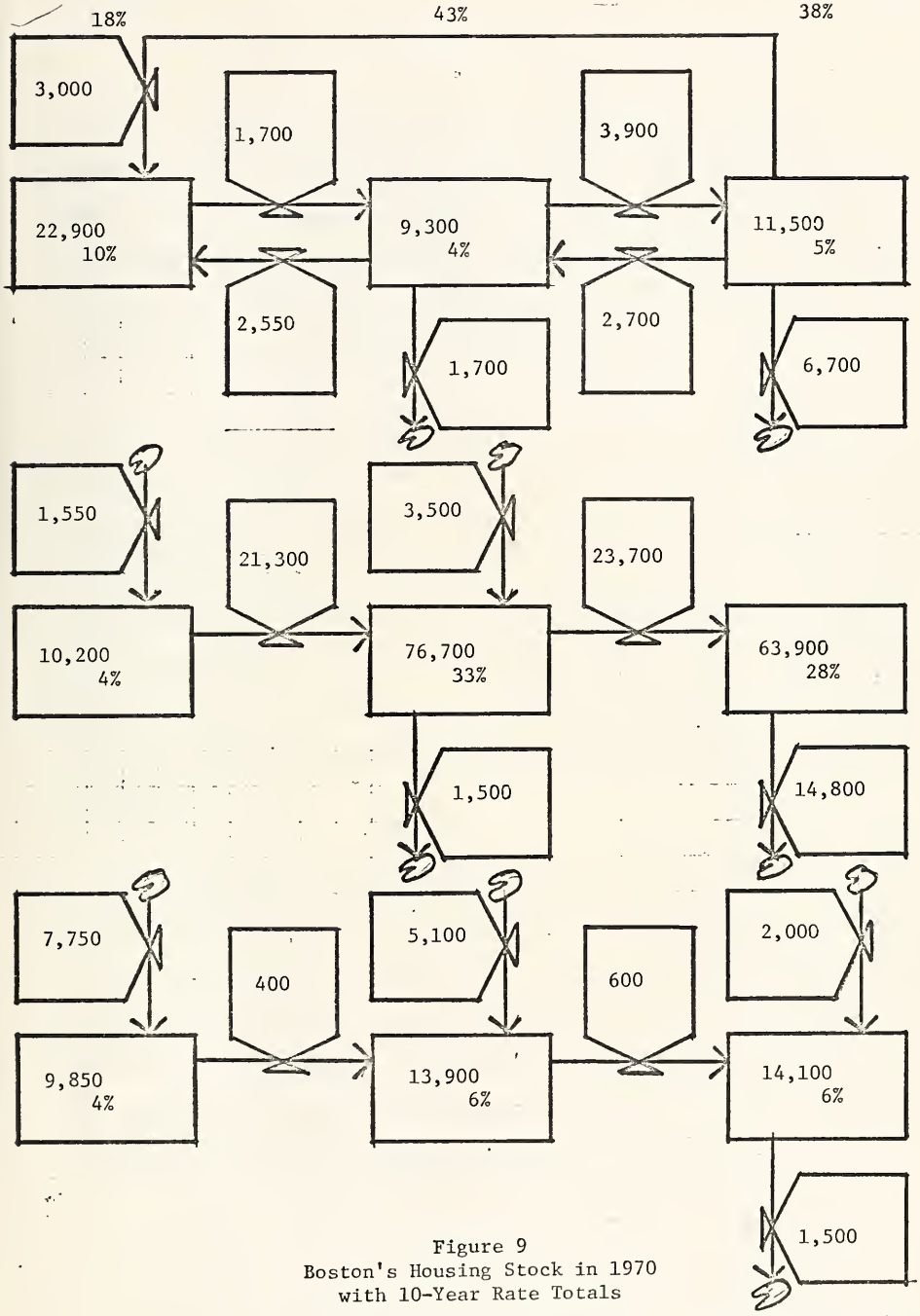

Figure 9
Boston's Housing Stock in 1970
with 10-Year Rate Totals

total stock: 232,500 units

total construction 19,900
total demolition 26,200

the next four figures show the 1980 results of four strategies. Figure 10 shows continuation of present trends. Figures 11 and 12 show results of assumed BRA strategies to construct more apartment buildings. Figure 13 shows consequences of a strategy to preserve and expand wood family housing and discourage apartment construction. A summary of the main features of each Figure follows.

Figure 10: Current Trends. The masonry sector in Figure 10, on page 17, assumes continuation of rehabilitation of housing in areas such as Back Bay and South End. Demolition slows considerably. Wood structures continue their rapid filter-down and the number of low income wood structures increases in spite of considerable demolition. Apartment construction continues at the 1960-1970 pace. Total construction evenly balances total demolition. Although total housing stock remains constant, because of declining household sizes city population falls slightly.

Figure 11: Moderate Construction. In Figure 11, on page 18, the masonry sector remains unchanged over the trend projection in Figure 10. Greater emphasis on preservation of low income wood housing decreases demolition while maintaining better quality housing. Increased construction of all types of apartments leads to more apartment units. The decade adds a net of 12,250 units to the housing stock but does not significantly alter the income distribution of the stock.

Figure 12: Significant Construction. Again, the masonry sector remains unchanged. Neither does the wood structures sector change over Figure 11. Emphasis on apartment construction raises the percentage of post-depression apartments to 34% of all housing. Income distribution does not change. Due to construction of 57,450 units and demolition of only 17,000, the total housing stock increases to 274,000 units.

Figure 13: Family Housing. In Figure 13, on page 20, the masonry sector remains unchanged. Significant construction efforts to build wood housing units for middle and moderate income families increases the rate of filter-down to low income housing. Increased demolition of the poorest quality low income wood housing should raise average housing quality. Depressed rates of apartment construction lead to less total construction than total demolition. Boston's housing stock falls by over 20,000 units. Note, however, the change in distribution percentages: fewer low income and fewer apartment units. Presumably such a housing strategy would be accompanied by a job strategy that upgrades low income families in moderate income status.

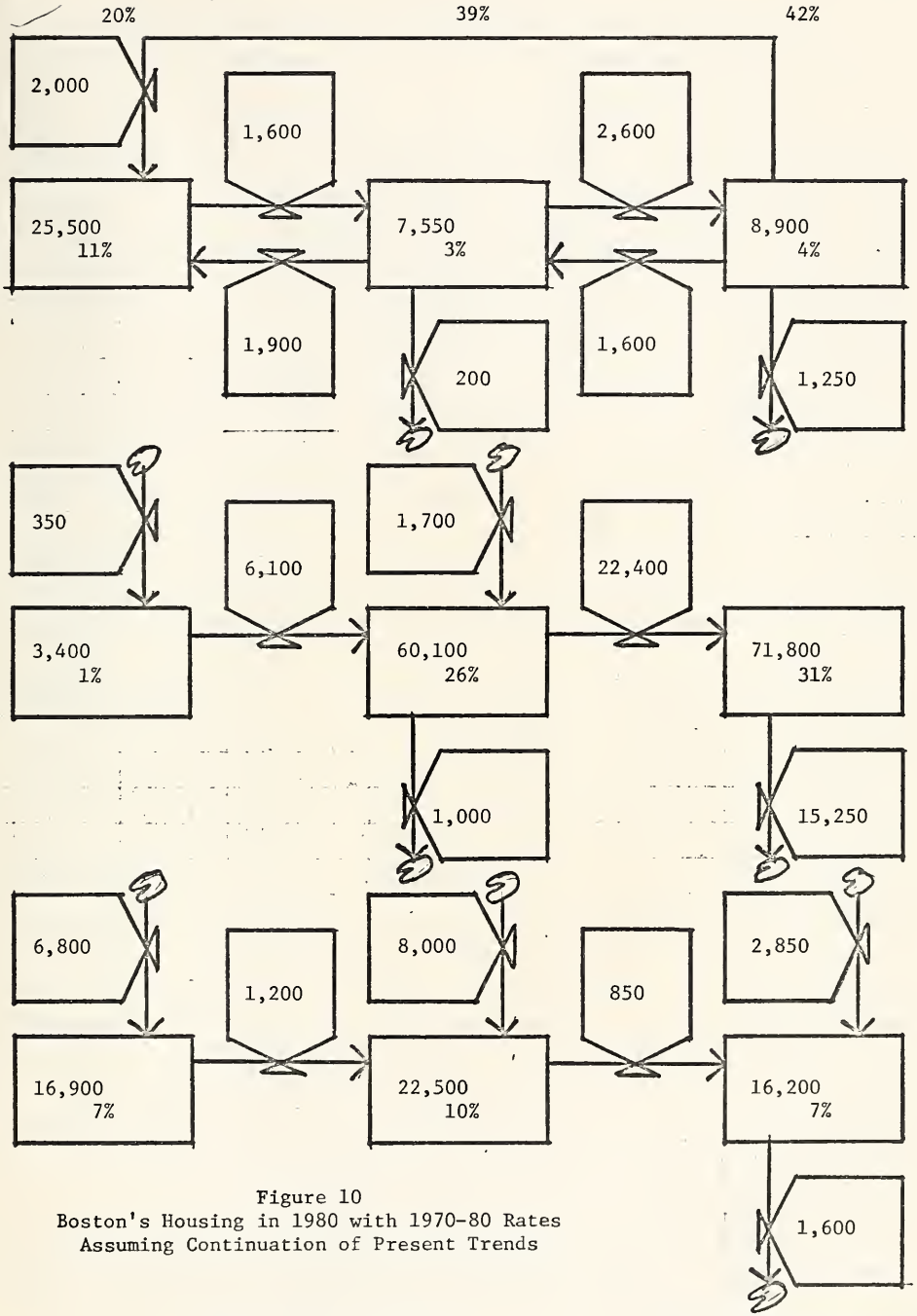

Figure 10
Boston's Housing in 1980 with 1970-80 Rates
Assuming Continuation of Present Trends

total stock: 232,800

total construction 19,700
total demolition 19,300

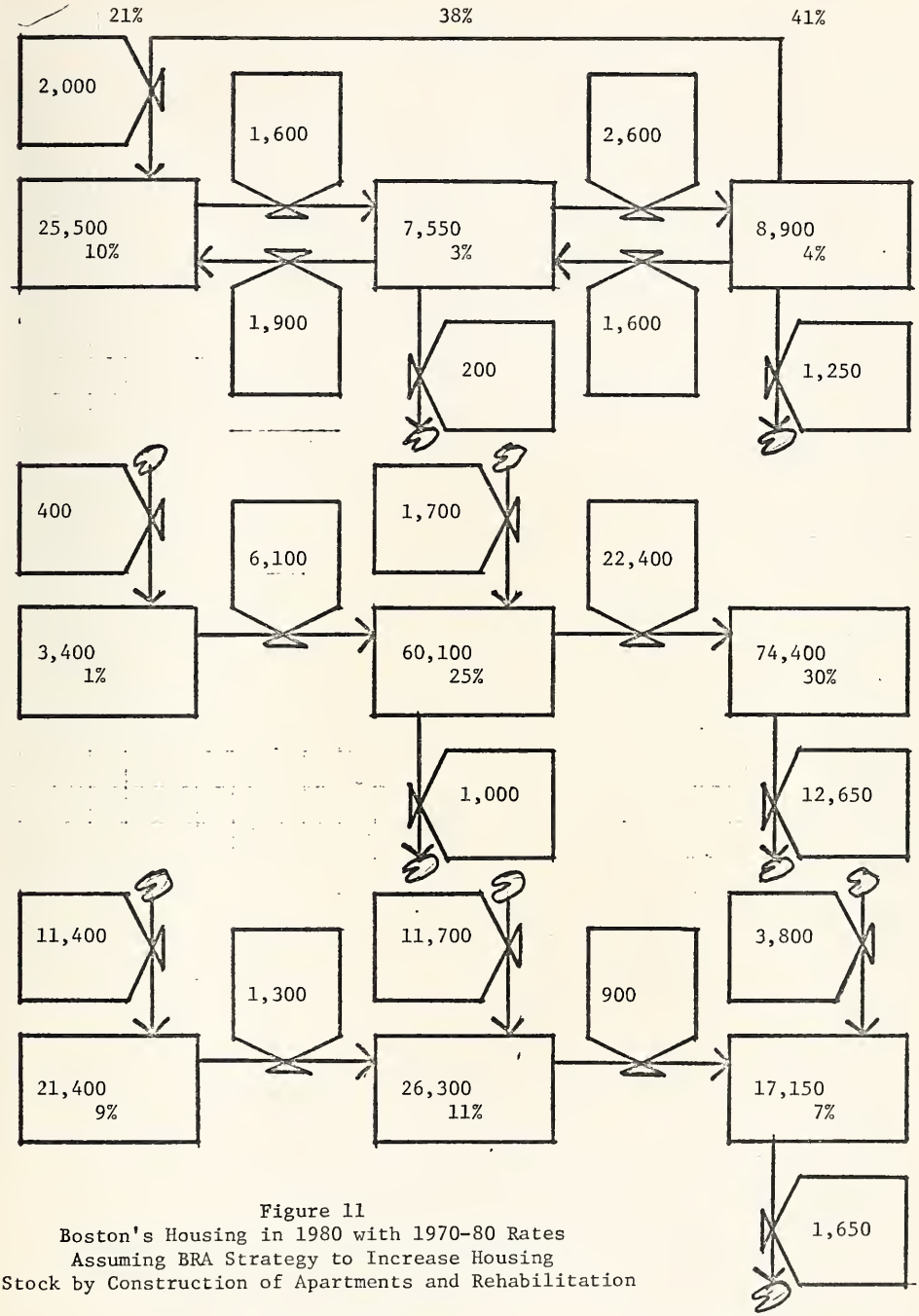

Figure 11
Boston's Housing in 1980 with 1970-80 Rates
Assuming BRA Strategy to Increase Housing
Stock by Construction of Apartments and Rehabilitation

total stock: 244,600

total construction 29,000
total demolition 16,750

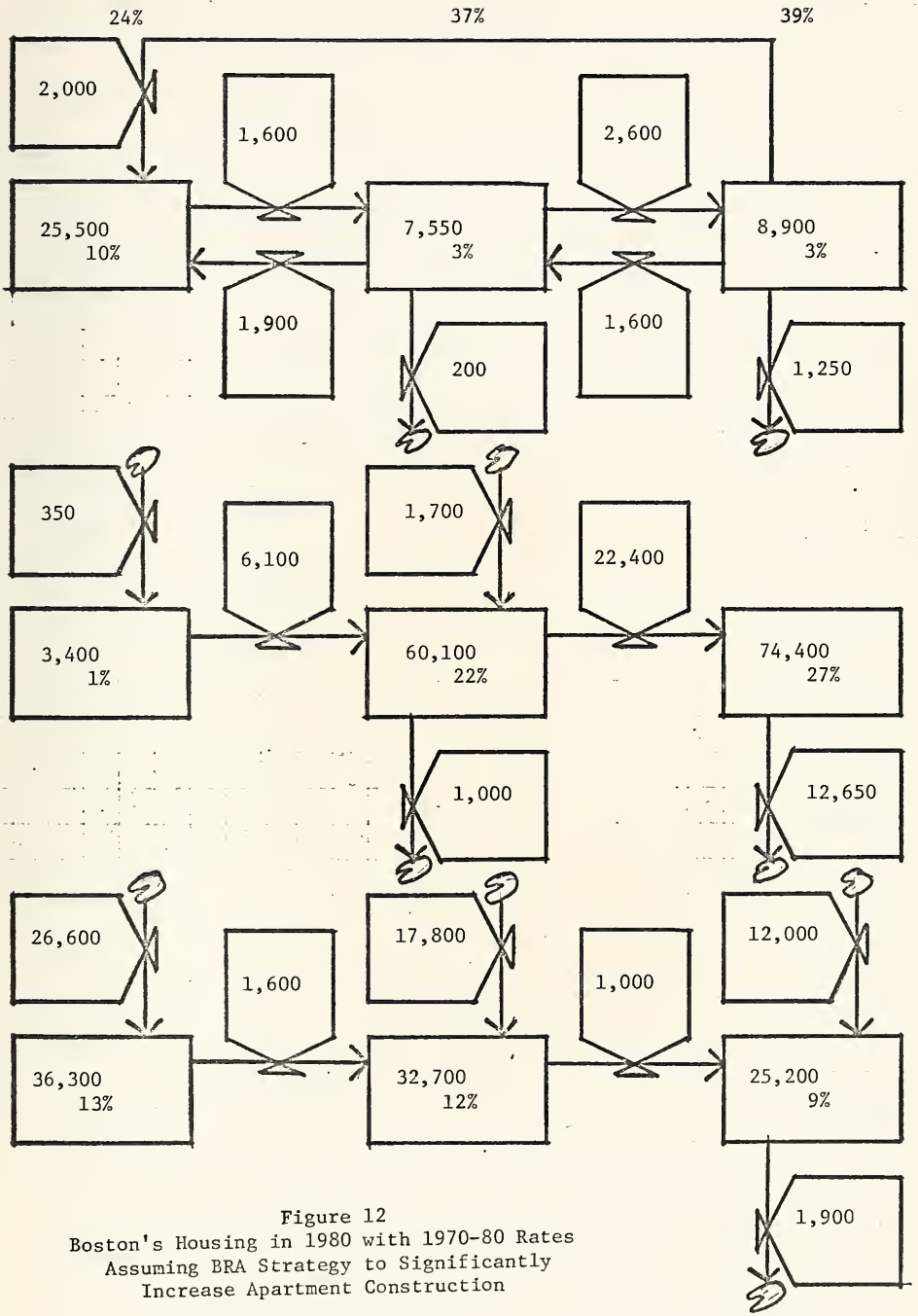

Figure 12
Boston's Housing in 1980 with 1970-80 Rates
Assuming BRA Strategy to Significantly
Increase Apartment Construction

total stock: 274,000

total construction 57,450
total demolition 17,000

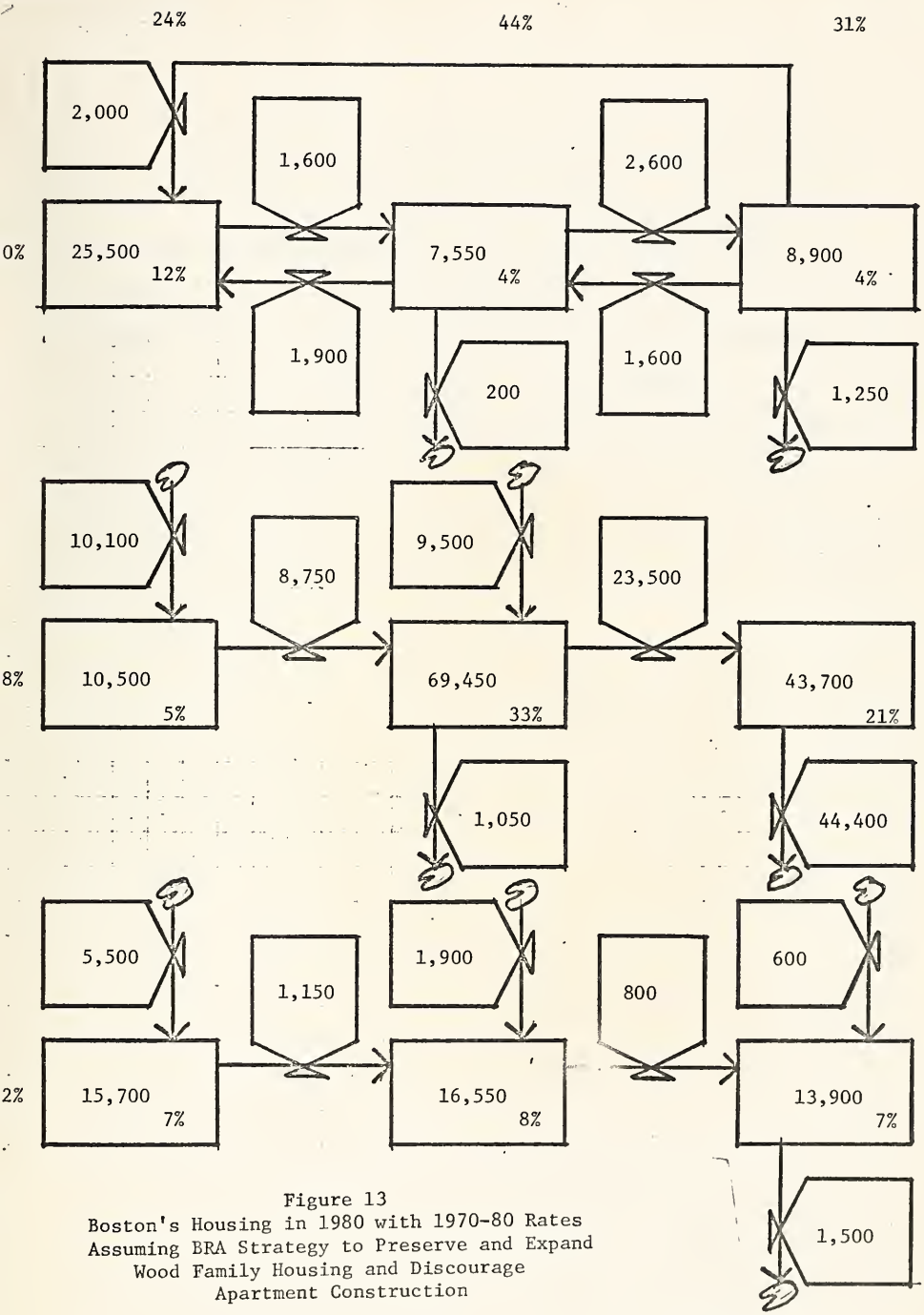

Figure 13
Boston's Housing in 1980 with 1970-80 Rates
Assuming BRA Strategy to Preserve and Expand
Wood Family Housing and Discourage
Apartment Construction

total stock: 211,600

total construction 27,600
total demolition 48,400

Conclusions. The illustration of housing policy analysis given above, although incomplete, conveys a sense of urban dynamics modeling. A full Boston model, tying housing and population to changes in the local economy, must await a subsequent phase of the BOSTON Project. Meanwhile, additional refinement and application of the housing model can improve design of BRA housing policy. For example, policy simulation over 20 and 30 year periods will provide a longer time horizon for present policy design. At this time, however, discussion of the merits, shortcomings, and intended application of the housing model will aid further model refinement and policy analysis.

March 15, 1974 Systems Dynamics Group

The BOSTON Project

Rejoinder to Discussion Paper #8
Assessing Boston's Housing Strategies
by Kent Colton & Rolf Goetze

The experience of working with Lou and urban dynamics has been very valuable to us in revealing the composition and trends affecting Boston's housing stock. The model has interesting "self-correcting" features that enable one to build on educated guesses and arrive at a reasonable approximation of reality.

However, there is also a certain "magic" to computer output that conveys a false legitimacy. We find ourselves starting to believe these numbers, and forgetting how rough the original "guesstimates" were. Where Lou uses the term "actual Boston data" as a validity test of the model (p. 12), this lends an unwarranted credibility on two counts. First, because the actual data at this point is still only a best rough guess, and second, because the model was "fitted" at the outset so it would match the data.

Our real concerns, though, hinge on the model's ambiguities, and its linear or mechanistic way of cranking out the future from trends in one decade. Let us elaborate these points.

Ambiguities. When housing filters down in the model, this may indicate lower income households taking over, or the same household remaining, but being in a relatively less affluent position. A shift may occur in the number of high income households depicted by the model, when in reality little or no shift has occurred in the housing. For

example, West Roxbury and Hyde Park were viewed as "High Wood" in 1960, but by 1970 many of these same owners had aged to "Moderate Wood." On the other hand, "Low Wood" or "Low Masonry" may have been rehabilitated and occupied by subsidized households during the 1960's under government programs. Condition may be better than before, but there is no shift as perceived by the model.

However, because of the ambiguity in the model between income levels and housing condition, one easily forgets such factors and assumes filtering down equates with deteriorating condition, or occupancy by new, less affluent households.

Linearity. The model devises aging or filter down rates for each stock type. However, consider "High Masonry." Such housing was originally built in the then fashionable South End in the 1840's and 50's. By 1960 much of this stock was receiving considerable wear and tear while housing lower income groups. Now, partially taken over by higher income groups, the future prospects for what wasn't demolished are quite strong. We could assume either 1) the less durable portion of this stock has been weeded out, or 2) that the life expectancy of this stock is a direct function of the class of users. Neither of these would result in a linear filtering rate.

Finally, we wish to warn against overlooking the realities and human dimensions of policy implications - e.g. Figure 13 proposes "increased demolition should raise average housing quality" (p. 16). Here the model may lead us to believe that by demolishing 44,000 lower income units their occupants achieve better incomes. History shows such upgrading is not automatic but that the same households simply take over adjoining units. If their incomes remain unchanged, then in the model more housing simply filters to this group, since the model defines

"Low Wood" simply by the income class occupying this housing. Further, if 44,000 housing units are to be demolished there are various human and political factors that must be considered.

How can the model reflect the impact of the energy crisis? Or of a direct income assistance strategy? Would housing allowances improve housing conditions more than subsidized lower income production?

Again, we wish to endorse the use of the model because of the way it can sharpen perceptions and help develop a common vocabulary among housing policy makers -- if the above caveats are borne in mind. We look forward to testing alternative policy implications with the Parkmen Center System Dynamics Housing Sub-Group.

Alfeld, Louis Edward.
Assessing Bos. housing strat-
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